Province of British Columbia

Ministry of Provincial Secretary and Government Services

Planning and Analysis Branch

ERGONOMICS:

VIDEO DISPLAY TERMINALS

AND PRODUCTIVITY

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INTRODUCTION

Interrelationships among human beings, technology and related environments are the subject of ergonomics. It is not a new concept, as relationships between machines and human physical characteristics have existed throughout history. From the Greek words ergos (work) and nomos (natural laws), ergonomics studies interactions between people and their work environment.

Figure 1. Sixteenth Century Armoury. Equipment and machinery designed to fit human physical characteristics (Derry and Williams)

Fredrick Taylor (1856 - 1915), the Father of Scientific Management, implemented procedures and facilities creating considerable production efficiencies, using the notion that machines and their environments should be coordinated with physical operator characteristics to obtain maximum potential production. The modern industrial era, however, has focussed attention on improving output capabilities of machinery. The agricultural industry, for example, has seen the tractor replace the horse. This is because a single tractor and operator can produce the equivalent of about forty farm workers with horses. The assembly line factory phenomenon and related technological improvements contributed additional output at a lower per unit cost.

The information industry has also witnessed massive technological change. The printing press economically produced far more documents than hand writing could do. Telephones and telegrams provided an abundance of immediate information. Typewriters and adding machines contributed further output capabilities to the office. Most recently, computers and word processing machines have demonstrated additional cost effective output capabilities. However, with all the technological advances of the 20th century, we've forgotten about man, in a sense. We've been more involved with mechanization and technological capabilities than with the total system, which includes human operators.

Growth of the white-collar work force, along with the proliferation of office automation and changing attitudes about the relationship between equipment and user, have made ergonomics a subject of current important concern. Robert Pew, Chairman and President of Steelcase Corporation recently stated that, "We've probably seen more change in the office in the past five years than in the preceding 50. Every year, more people are putting more hours into office work."

Figure 2

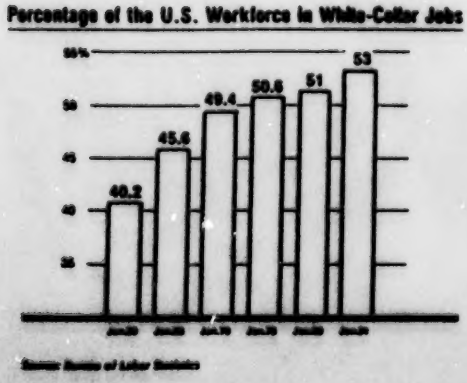
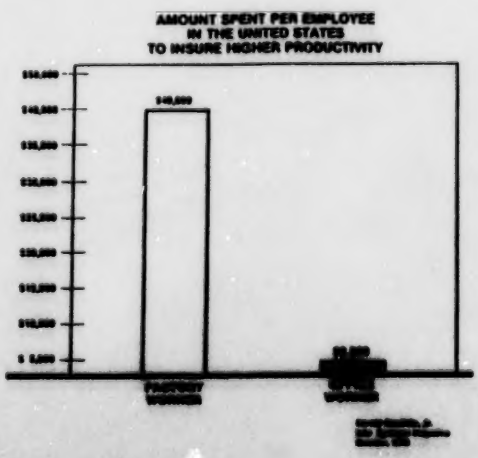


Figure 3



The U.S. Bureau of Statistics reports that the 'white collar' worker population represents over 50 percent of the total employed work force in the United States. The office has suddenly taken on a new dimension, as business people everywhere have begun to seek innovative ways to bring the kinds of efficiency and productivity to the office that the factory has enjoyed for many years. At the moment there is one video display terminal for every 20 desks in North American offices. By 1990, there will be one for every three desks. When the year 2,000 arrives, it is expected that 66% of the work force - a full two-thirds - will be employed in information services. The shift from agriculture and labour to white collar work will continue, and as we accelerate automation of the office there will be an increasing need to combine technological innovations with human physical characteristics, in order to maximize productivity, as well as operator self satisfaction.

The information explosion resulting from the electronic revolution is causing the nature of the office environment to change. In the past, the office was considered to be a static place, or a fixed point in the dynamic world of operational activity. It was a place where paper records were filed and stored. It was a home for the business information process. However, the office is rapidly becoming involved in a much larger picture. As Roger Yee, Editor, Corporate Design Magazine, explains, "Corporate facilities are really productive capital goods. They produce decisions." As a consequence, offices are becoming areas of constant change, where people, equipment, furniture and work flow must not only be efficient, but must also be very flexible in order to maximize benefits from contiually improving technology.

DISCOMFORT, FATIGUE AND PRODUCTIVITY

More than one-half of our active lives are spent in a work environment. However, very few furniture designs have, until now, attempted to deal scientifically with operational frustrations affecting employees. Frustration can have a direct impact on productivity, especially if relief is not offered. It lowers morale, causes absenteeism and turnover, and can result in work stoppages.

Figure 4.

Poor posture: no adjustable backrest to support spine; chair height fixed posing problems for tall and short individuals; lack of document holder causing excessive head and neck twisting and bending – overall situation leading to fatigue and eyestrain.

Source: B.C. Ministry of Labour

Some employees become aggravated by discomfort and temporarily stop working. Often leaving the workstation completely, this "on-premises" absenteeism has become a serious wasted expense item of many companies. At one major corporation, a departmental study showed that the full-time employees were actually working only half the day. Consider for a moment the cost implications of this unproductive time. Assume:

a) the existence of a standard operation having 50 employees, with;

b) average annual salary per employee: $18,000

Then, annual cost of unproductive time would be:

(1/2 x $18,000/yr. x 50 employees) = $450,000

Cost of improved ergonomic facilities:

($500 per station x 50 employees) = $25,000

Then, annual potential value of improved productivity would be:

($450,000 - 25,000) = $425,000

Considered from a different perspective, it has been shown that every 10 minutes of daily operator time lost, costs the employer about $400 per year, as illustrated in Figure 5.

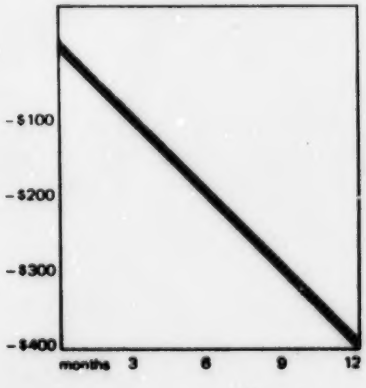


Figure 5

A 10 minute daily loss of productive labor can cost an employer $400 per employee annually.

Opinion Research Corporation of Princeton, New Jersey reported that clerical workers job satisfaction declined 10% between 1970 and 1977. Some workers even sabotage equipment to relieve frustrations they find in their work environments. Social scientists report that such sabotage ranges from disabling a piece of office equipment to malicious destruction of larger pieces of machinery.

Industry is turning to science to help reduce frustration in the work place. The science of ergonomics, or human factors engineering, studies the relationship between man and machine in an attempt to make machine design and environment more responsive to human needs.

As change occurs increased emphasis is placed on productivity, not only in terms of developing new measuring methods, but more importantly in relation to improving efficiency, with particular emphasis on equipment design. Results of several prominent studies in the United States clearly indicate that when operators are provided with efficiently designed environments in terms of acceptable posture, light and sound facilities, productivity can significantly increase, along with quality of life to the operator.

POSTURE, LIGHT AND SOUND

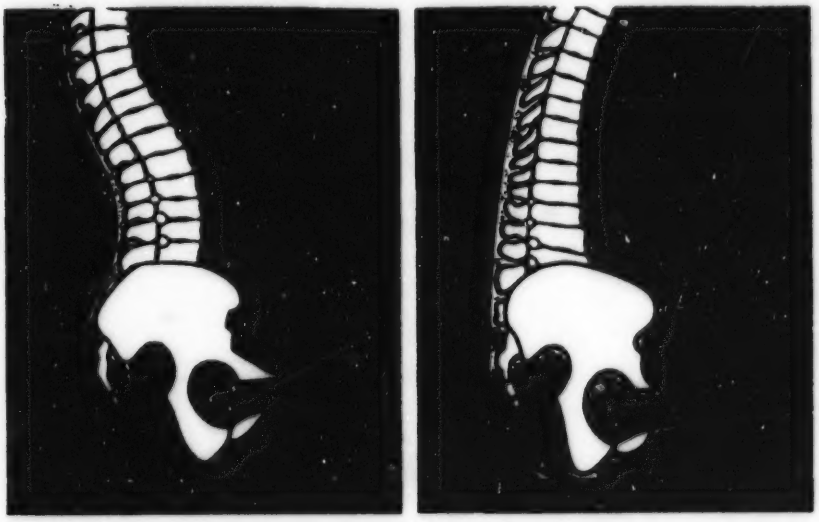
Three critical elements of ergonomic concern are seating, light and sound facilities. They each affect organizational production.

Posture

More than half of our active lives are spent sitting, during which time we change positions at least every eight to ten minutes. A major consideration for maintaining a healthy back in a seated position is to have postural support and comfort as well as the ability to move from a forward-leaning, work-intensive position to different states of vertical and reclining positions of support. "One of our biggest problems in

office safety is backs," says Stan Field of I.B.M.. Striking more frequently than the common cold, back pains put more than 80% of our population in doctor's offices at some point in life and cause more lost work than any other on-the-job disability.

Figure 6



Illustrated are two undesirable extremes of sitting postures. An improperly designed seat and backrest, as in diagram D, forces an exaggerated spinal curve (lordosis). The opposite extreme is slouching (kyphosis), as in diagram E. The flat seat contributes to reversal of the natural spinal curvature. Either extreme may result in lower back strain.

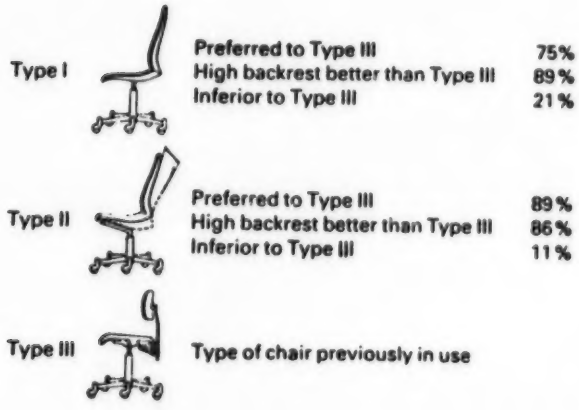
Source: Open Ark Center for Design Research and Development

In 1980, Louis Harris and Associates conducted a study entitled "Comfort and Productivity in the Office of the 80's". They summarized the opinions of a cross-section of 1,004 U.S. office employees and executives. In relation to seating, 73% of the office workers said a comfortable chair affects their performance a great deal. Seventy-eight percent said their office chair was as important or more important than their favourite chair at home. In addition, 58% believe a choice in chairs would increase their productivity. The area where chairs may make the most noticeable difference is at computer terminals which, like aircraft, require close attention and where, also like aircraft, the

tiniest error can cascade into a serious problem. Since an estimated 250,000 VDT's are currently used in Canada, ergonomics is becoming increasingly relevant.

Scientific application to the design of office seating has demonstrated what scientists have claimed for at least two decades - alertness and productivity become improved when seat and back contours are designed to fit the user.

Figure 7


Type I
Preferred to Type III 75%
High backrest better than Type III 89%
Inferior to Type III 21%
Type II
Preferred to Type III 89%
High backrest better than Type III 86%
Inferior to Type III 11%
Type III
Type of chair previously in use

A seating system should offer a variety of well-designed chairs. While their functions - automatic support in several positions - should remain constant, the features of an individual chair should vary with the physical stature and job demands of the worker. Large frame people are suited to large size chairs, medium frame people, to medium size chairs and small frame people to smaller size chairs. If several operators of a similar stature, but of different heights share a video display terminal, an automatic air-lift seat adjustment has the ability to quickly accomodate the height requirements of all operators. The work surface,

or desk, should also be practical and somewhat adjustable to accommodate keyboard and terminal height adjustment. Another postural aid is a graduated footrest, particularly for shorter people who operate the same terminal(s) as tall people.

The intention of these explanations is not to imply that management should immediately purchase such items, but rather when planning for replacement, or adding to facility requirements, ergonomic characteristics, as well as related cost factors should be considered. The cost of ergonomic technology tends to be decreasing with the passage of time. For example, a Canadian made ergonomic chair designed to suit a small frame person currently costs about $120. An effective medium size chair can be purchased for about $150 and a very popular large size imported chair presently costs about $400.

Lighting

Another area of ergonomic concern is lighting. According to the majority of published expert opinion, it is unlikely that VDT's produce damaging or disabling eye conditions. What documents have indicated, however, is that failure to accommodate the operator in VDT design, implementation and use may result in health concerns. It is often incorrect positioning of source data and not the terminal that causes eyestrain. Too much light, either directly or reflected, causes eyestrain to VDT operators.

In the past, it was concluded that since office layout usually changed continuously and it was never known what function would be located in what area, the only long-term solution was to put maximum lighting

throughout the office. With so much brightness on work surfaces however, the contrast that operators' eyes must adapt to during their frequent movement between the terminal screen and source data is extremely straining. In addition, light sources reflecting from a video display screen also create eyestrain. Reading a terminal screen with light reflections on it is much like trying to see through a dirty car window when driving into the sun. The light image obstructs vision.
Lighting conditions must also be responsive to different ages of operators. It is a medical fact that the older we get, the more light we may require to see. Someone 40 years old can require twice as much light as someone 20. A 60 year old person can require four to five times as much.

Various methods are available for improving lighting conditions and related productivity of VDT operators. At times, there is a need for lowering and tilting the VDT screen away from the operator as one method of resolving a reflection problem. The use of parabolic wedge louvres as well as document holders and task lamps with low-level general office lighting are other popular methods of improving lighting conditions for VDT operators. Repositioning the terminal and desk, as well as the prudent use of room dividers, are other methods commonly used to improve visual conditions. Display terminal filter screens have also experienced favourable results in some areas. The avoidance of glossy furniture finish also contributes significantly to reducing harsh lighting environments. Instead, the use of a matte or unshiny finish tends to absorb light rather than reflect it. Uncontrolled light levels create operational strain, stress and fatigue resulting in less than optimum potential production.

Noise

Noise is another element that adversely affects office production. An observation of the Harris study was that "the most important characteristic for getting the job done well was the ability to concentrate without noise or other distractions." Cutting down on the amount of noise and distraction in the office is perceived as very important to office workers." A two-year study with printer covers at Aetna Life Insurance brought an 8.8% improvement in office efficiency. A noise reduction of 80% at operator ear level improved operator efficiency because of less fatigue, thereby improving employee productivity. Many factors interfere with office productivity. Managers and employees must become completely educated with related problems and solutions if they hope to improve production, in terms of increased efficiency and effectiveness.

Comfort and Productivity

Responsible purchasers are giving the comfort factor greater consideration when selecting office equipment and furniture, as recent findings indicate a direct link between comfort and productivity. Results of the Harris Study indicate that 84% of executives and 80% of office workers believe that better working conditions result in increased productivity. According to Harris, white collar workers draw a strong connection between their office comfort and their job performance. A majority feel that there is a potential for greater productivity, fewer errors, more concentration and increased motivation if the comfort level is raised.

Surprisingly, office workers share management's concern for improved productivity. Thirty-five percent feel they probably could do more than they're doing now. Ninety-two percent see a direct relationship between environment and job performance. In addition, 74% feel they could do more in a day if their working conditions and environment improved.

Frustration, unawareness and apathy create stress, fatigue and less than optimum production levels. In a report for A.B. Dick Company, Towers, Perrin, Forster and Crosby explain "the pressure to produce faster and more efficiently has never been greater, and the human factor is painfully trying to keep up with a technology that pulls further and further away from it." When asked to define the most important issue in office design today, and during the next ten years, business executives named employee productivity as the primary element of interest. Architects and professional designers also named employee productivity as the number one office concern today. Such findings leave purchasers with the added responsibility of ensuring that workers are satisfied with their equipment, and allow the opportunity for increased productivity - another way in which purchasing can add dollars to an operation's profit and loss statement.

CONCLUSIONS

With the future, there is a challenge to introduce the human factor into the design of machines, making machines and their environments more responsive to the needs of those who use them. We are now aware that technology, besides increasing efficiency and shortening production time,

can help in reducing fatigue and frustration as well. The science of ergonomics is expected to receive additional attention in the years ahead. Tom Stewart, one of Europe's leading ergonomics experts, says that "Ergonomics can be highly cost-effective through reduced error rates, increased productivity and improved staff morale and motivation." Both business executives and designers agree that the most important issue in office design and planning today is employee productivity and they feel that this issue will gain importance during the next ten years.

The key to a successful office system will be its ability to permit people to feel that they are controlling the system, rather than being controlled by it. If the executive is to achieve the desired results of a system, it must be accepted by the people in the office and therefore the people productivity factor must be seriously considered whenever technological change is anticipated. "Let's face it," explains Michael Hollett (WCB Report), "the workers themselves are the ones who best know if, say, a chair is uncomfortable or if the lighting in an office is too bright. It makes sense to encourage them to participate in the design."[8] Henry Dreyfuss, in the text Designing for People, agrees. "We bear in mind that the object being worked on is going to be written in, sat upon, looked at, talked into, activated, operated, or in some other way used by people individually or in mass. When the point of contact between the product and the people becomes a point of friction, then the industrial designer has failed. On the other hand, if people are made safer, more comfortable, more eager to produce -- or just plain happier -- by contact with the product, then the designer has succeeded."

The fact that a nearly unanimous 92% majority of office workers perceive a connection between their personal satisfaction with their office surroundings and their job performance places added emphasis on the importance of office planning and design that does indeed meet the needs of office workers. It is, moreover, strong evidence for the argument that office planning should not be given a low priority status when increases in productivity measures are considered. In The Journal of Methods — Time Measurement, Tom Erickson adds, "The focus (today) is on the human factor. This has become increasingly important and one of the reasons I see it evolving in the eighties. These changes in management of the human resources and the work environment will have a significant impact on productivity improvement. Those that make the transition effectively will have the competitive edge."

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